REMARKS

The Final Office Action mailed on August 28, 2003 has been reviewed carefully and the claims have been amended in a sincere effort to place them in condition for allowance.

Claim Rejections - 35 U.S.C. § 102

Claims 6, 7, 11 and 12 were rejected under 35 U.S.C. § 102(e) as being anticipated by Bahar et al., U.S. Patent RE37,656E ("Bahar").

Briefly, Applicants' invention involves a direct oxidation fuel cell, such as a direct methanol fuel cell ("DMFC"), which includes a layered membrane for a membrane electrode assembly ("MEA") that supports a high level of protonic exchange in the direct oxidation fuel cell, yet significantly controls excess carryover of water and fuel crossover within the fuel cell.

In conventional membrane electrode assemblies for fuel cells, a layer of protonically-conductive material the membrane electrolyte comprises the central or middle component of the membrane electrode assembly, with catalysts and diffusion layers being placed on each side of the protonically conductive membrane to create a membrane electrode assembly. Typical DMFCs do not manage fluid within the electrolyte itself, rather fluids are managed at the anode or cathode aspects of the fuel cell. More specifically, fuel is delivered to the anode side of the MEA, and fuel and water react in the presence of the catalyst to produce a reaction generating protons, electrons and car-

bon dioxide. The protons travel through the membrane electrolyte to the cathode side, and the electrons travel across a load to provide power to a device or battery. On the cathode side, oxygen is reacted on the cathode catalyst and combines with the protons to produce water.

Applicants' invention employs a "barrier layer" as the central layer in its MEA to control liquids travelling within the fuel cell. For example, in some fuel cell systems, water is externally recirculated from the cathode to the anode in a controlled manner depending upon the desired fuel concentration, and other considerations. In such systems, it may be undesirable to allow additional water to travel across the membrane electrode assembly from the cathode side to the anode side, thus creating excess water on the anode side. Applicants' barrier layer prevents such travel of water. In addition, fuel can crossover from the anode to the cathode and can react on the cathode catalyst thereby wasting fuel (because such a reaction does not contribute to the production of electricity) and creating heat. Applicants' barrier layer prevents fuel from crossing over the membrane from the anode side to the cathode side, and resists water from travelling from cathode to anode.

Applicants' barrier layer is the substrate in a sandwich-type configuration in which layers of protonically-conductive material are placed on each opposing aspect of the barrier layer to form a layered membrane electrode assembly. The barrier layer itself is substantially protonically non-conductive, but it includes selected sites, that include passages, or openings, that allow protonically-conductive contact between the

membranes. This design allows substantial reduction of water carryover and fuel crossover, and thus the barrier layer acts as a seal to impede unwanted fluid travel between anode and cathode. However, protons can pass through the microperforations ("passages") in the barrier layer. In other words, as stated in the Specification at page 6, beginning at lines 21,

> The material used to fabricate barrier layer 34 should not be protonically conductive. Rather, the pores in the barrier layer 34 allow protonically conducting contact between PCMs 36a, 36b. The pores in barrier layer 34 need only be large enough (relative to barrier thickness) to allow PCMs 36a, 36b material contact through same, while remaining small enough to prevent the passage of liquid water, and to some extent methanol.

Bahar, on the other hand, describes an ion exchange membrane comprising a composite membrane that has a porous microstructure, such as a mesh, upon which NAFION® (a protonically-conductive material) is painted to coat the porous material with the NAFION® thus creating a protonically-conductive membrane. The mesh provides strength and stability as a base, but the primary material exposed to the reactants and products is NAFION®. Applicant's MEA is not a mesh that is coated or filled in with NAFION ®. Instead, Applicant's internal barrier layer in the MEA acts to physically separate the NAFION® layers in order to manage water and fuel flow by impeding passage of fluid from anode to cathode, and vice versa.

The Bahar reference includes teachings about pores, but the pores are the openings in the mesh material, which as taught by Bahar are filled, or impregnated, with NAFION®. The reason for this is stated to be so that the resulting membrane is air impermeable and protonically conductive, so as to improve conductivity. Bahar is not providing solutions for the management of fluids within the fuel cell, or more specifically, within the MEA.

In order to clarify this aspect of the invention and to enhance the distinctions that the invention has over the prior art, claims 6, 7, 11 and 12 have been amended either directly or through dependency. More specifically, independent claim 6 now states that it includes: "a <u>barrier</u> layer of material <u>that is substantially protonically non-conductive and</u> which is substantially impermeable to water and carbonaceous fuel." Furthermore, the barrier layer includes: "selected sites <u>comprising openings providing passages through</u> said <u>barrier</u> layer enabling protonically conductive contact <u>through said passages</u> between said first and second membranes." Claim 11 has been similarly amended.

For these reasons, it is respectfully submitted that amended claims 6 and 11 are now in condition for allowance. Similarly, the claims dependent from those claims are also now in condition for allowance.

Claim Rejections - 35 U.S.C. § 103

Claims 1, 2, 5, 10, 15, 16, 19, 20 and 23 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Bahar, as stated in the previous Office Action.

The Examiner has indicated that the Applicants' invention as a whole is obvious to one of ordinary skill in the art based on the teachings of Bahar, in that Bahar may be used for a fuel cell with improved ionic conductance and water transport across the membrane requiring less fuel gas humidification.

Applicants' invention includes using a barrier layer to control liquids within the fuel cell such that fuel cross over is avoided and excess water transport is avoided. As noted by the Examiner, Bahar appears to be describing fuel cells in which it may be important to encourage water transport across a membrane (Col. 10, lines 58-65 of Bahar), but in so doing, Bahar is teaching away from Applicants' invention because one of the primary goals of Applicants' barrier layer is to resist water crossing the membrane, and to keep un-reacted fuel from crossing over from the anode side to the cathode side. Thus, Bahar, in fact, teaches away from Applicants' invention and thus does not render Applicants' barrier layer obvious.

The Examiner indicated that middle layer of Bahar is protonically-conductive, but Applicants claims do not limit the protonic conductivity of the claimed layer. Accordingly, Applicants have amended claims 1, 2, 5, 10, 15, 16, 19 and 20, either directly or indirectly through dependency, to recite that the barrier layer is "substantially protonically non-conductive," and that the passages therethrough allow the protons to travel between the two layers of NAFION®.

SUMMARY

All of the claims have been amended herein, either directly or through dependency. It is respectfully submitted that these claims are now in condition for allowance. Please do not hesitate to contact the undersigned in order to advance the prosecution of this application in any respect.

Please charge any additional fee occasioned by this paper to our Deposit Account No. 03-1237.

Respectfully submitted,

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